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MIGRATING BIRDS AT A STOPOVER SITE IN THE SAINT CROIX RIVER VALLEY

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ABSTRACT.—We captured 16,527 birds in five habitats at Sandrock Cliff, Saint Croix National Riverway, during spring and fall of 1985, 1986, and 1987. Nearctic-Neotropic migrants comprised 66% of the 118 species captured. They comprised the majority of individuals taken in spring (82.5%), autumn (68.9%), and overall (72.7%). Nearctic-Neotropic migrants averaged 15 weeks between median capture dates, arriving later in spring and departing earlier in fall than temperate zone migrants. The latter spend about 20 weeks elsewhere between median capture dates. Differences in spring and fall capture rates in five habitats suggests birds shift habitat use seasonally. *Received 11 May 1992, accepted 25 Nov. 1992.*

The biological community and habitat requirements of long distance avian migrants along their regular annual migration routes are known poorly, and the relative importance of particular habitats to the migrating populations remains to be determined. Most observers are aware that survival of migrating populations is dependent both upon successful reproduction during the northern summer season and a successful non-breeding wintering period in the tropics. It also appears the non-breeding portions of the long distance migrants' life cycles are as critical to survival of the population as the reproductive periods (Recher 1966, Rappole et al. 1983, Berthold and Terrill 1991). Because similar economic and technological pressures exist for both regions, one may assume reasonably that North American habitats used during annual migrations may suffer reduction and fragmentation similar to that occurring in tropical America (see Robbins 1979, Robbins et al. 1989, Terborgh 1989, Finch 1991). The elimination of habitats necessary for resting or replenishment during migration could adversely affect migrating individuals, because morphological adaptations limit the habitats where resources are used efficiently (Parnell 1969, Bairlein 1992). Constraints on habitats used during migrations may also be imposed by predation potential and other environmental stresses (Moore and Simon 1992). Consequently, we undertook a descriptive study of migration and habitats at a stopover site used by migrating birds in the Saint Croix River Valley in Minnesota during 1985–1987. Here we summarize our findings.

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METHODS

The Saint Croix River lies near the center of North America, where it forms part of the boundary between Minnesota and Wisconsin, connecting the Lake Superior basin with the Mississippi River (Ojakangas and Matsch 1982). This valley encompasses diverse biotic communities with boreal elements along the northern reaches of the river, and hardwood forest species in the middle and prairie-savanna communities along the most southerly reaches. The climate is characterized by warm summers and cold winters with a mean annual temperature of 5.5°C and an annual range of 85°C, while precipitation (melted) varies from more than 100 cm in the north to about 70 cm in the south (Graczyk 1986). Sandrock Cliff is a semi-remote site amid abandoned river channels and extensive forest lands logged during the 19th Century. It is in the Saint Croix National Riverway at river km 146 (45°47′30″N, 92°45′30″W), Burnett County, Wisconsin. An alder swale, a conifer swamp, an island floodplain forest, a pine barren forest, and an upland hardwood forest were selected as five primary habitats for study during spring and fall of 1985, 1986, and 1987. The upland hardwood forest site was eliminated after 1985. It was replaced by a sedge fen habitat in 1986 and 1987 (Table 1). Unusually dry conditions dominated the weather beginning in fall 1986 and developed into a severe drought by summer and fall 1987 (see Blake et al. 1992). A companion site at Valley Creek, 100 km due south along the Saint Croix River, was operated from 1984 through 1986 (see Winker et al. 1992).

We designated each selected habitat by its dominant woody vegetation. Alder swale is a 40-year-old alder (*Alnus rugosa*) and willow (*Salix* spp.) thicket, 3–4 m high, on a former channel sandbar paralleling the present river channel for 0.6 km. Conifer swamp is a 140-year-old stand of 9–20 m high swamp conifers (*Larix laricina, Picea* spp., *Abies balsamea*) and moisture tolerant hardwoods (*Betula alleghaniensis, Fraxinus* spp.) occupying a 0.7 km-long abandoned oxbow channel. Juvenile firs and spruces, numerous ferns, and bryophytes abound amid standing water and boot-sucking quagmires that cover extensive areas. Floodplain forest is a 105-year-old riparian forest occupying a 0.4 km-long island subject to spring flooding. Basswood (*Tilia americana*), hackberry (*Celtis occidentalis*), ash (*Fraxinus* spp.), and elm (*Ulmus* spp.) are the common canopy trees in floodplain forest, with a dense summer ground cover of ostrich ferns (*Matteuccia struthiopteris*) and numerous graminoids. Pine forest is an 85-year-old stand of pines (*Pinus banksiana, P. resinosa*) and aspen (*Populus grandidentata*) on well-drained, sandy soils. There is a dense understory of hazelnuts (*Corylus* spp.), grey dogwood (*Cornus racemosa*) and various brambles (*Rubus* spp.). Upland forest is an 80-year-old hardwood forest comprised of oaks (*Quercus* spp.), ironwood (*Ostrya virginiana*), and aspens (*Populus* spp.) on a ridge paralleling the river for nearly 1.5 km. Sedge fen, adjacent to conifer swamp in an old oxbow channel, is an open expanse consisting of 0.5 m high hummocks of various graminoid species (*Carex* spp., *Phalaris* spp.) and scattered clumps of small alders (*A. rugosa*) and willows (*Salix* spp.). Standing water is present both spring and fall. These six habitats are typical of the tension zone in the middle reaches of the Saint Croix River Valley (see Curtis 1959).

A Brunton pocket transit, metric chain tapes, a Suunto clinometer, and range finders were used to establish net-lanes and lay out net-lane grids. Subsequently, a total of 0.6 ha vegetation sample areas were examined for each habitat. Plant species, stand age, vegetation structure, physical topograpy, and substrate were recorded for habitats, following a modified relevé (Mueller-Dombois and Ellenberg 1974) in which two semi-circle 0.025 ha plots ($r = 12.6$ m) were centered on each net-lane, one on either side of the excluded 2 m wide net-lane, totaling 0.05 ha for each net sampling area. Surface vegetation, vegetation characteristics, and substrate were recorded in two randomly selected 1 m^2 quadrats within each semi-circle plot. Increment borers and metric diameter tapes were used for tree data. Each habitat was marked with permanent numbered metal stakes at the end of the study in the fall of 1987.

TABLE 1

SAMPLING EFFORT (NET-H) FOR SIX HABITATS AT SANDROCK CLIFF, SAINT CROIX NATIONAL RIVERWAY DURING SPRING AND FALL MIGRATIONS 1985, 1986, AND 1987

Habitat	1985		1986		1987		Total net-h
	Spring	Autumn	Spring	Autumn	Spring	Autumn	
Sedge fen	0	0	5358	5965	5722	6601	23,646
Conifer swamp	6753	4916	5301	6198	5725	6622	35,515
Floodplain forest	4755	4919	3721	5101	5716	6598	30,810
Pine forest	5052	4912	5295	5965	5728	6640	33,592
Alder swale	5226	4898	5182	5962	5725	6622	33,615
Upland hardwood forest	6705	4306	0	0	0	0	11,011
Total net-h	28,491	23,951	24,857	29,191	28,616	33,083	168,189

Twelve mist nets (12 m × 2.6 m, 30 mm mesh) were placed in surveyed 210 m × 102 m grids comprising two parallel rows of six nets within each selected habitat. The 12 mist nets in alder swale were placed in a single line because it was less than 102 m wide along most portions. All nets were oriented 90° by 270° (magnetic) and placed at measured 30 m intervals, with at least 30 m to the nearest habitat edge. Thus, the minimum habitat size sampled was approximately 2.1 ha. Each habitat and net was identified by an alphanumeric sequence throughout the study, enabling specific site identification. Nets were operated daily from 0.5 h before dawn to 0.5 h after sunset from 3 to 31 May 1985, 28 April to 29 May 1986, and 27 April to 28 May 1987 in the spring (Julian dates 123–151, 118–149, 117–148) and 20 Aug. to 22 Sept. 1985, 18 Aug. to 25 Sept. 1986, and 17 Aug. to 28 Sept. 1987 in the fall (Julian dates 232–265, 230–268, 229–271). Starting and ending dates were determined primarily by logistic and funding factors. Nets were placed in the same position in each net-lane each season. The overall sampling effort was 35 and 43 days spring and fall, respectively. Nets were checked at 1.5 h intervals during operation. They were closed only during severe inclement weather or for rare logistic considerations. Night-time captures were uncommon. The 60 mist nets were operated simultaneously for a total sampling effort of 168,189 net-h for all habitats spring and fall 1985 through 1987 (Table 1). Mist net sampling does have biases affecting data attributes (Karr 1979, 1981), but since these biases are consistent each season and year throughout the study, our comments are limited to those birds for which we have data records.

Captured birds were identified to species, sex, and age by visual and manual examination. A series of additional measurements and observations was recorded for each bird, including collecting ectoparasites (see Weisbrod and Johnson 1989). The birds were banded with U.S. Fish & Wildlife Service bands and usually released within 0.5 h of capture. Field data records were transcribed directly onto laboratory personal computer systems each fall and winter following the field season. The observations presented here are based only on first capture data. Scientific and common names for bird species are provided in Appendix I.

RESULTS

We captured 16,527 birds representing 118 species during six seasons at Sandrock Cliff, of which 4645 birds (97 species) were taken in spring and 11,882 (105 species) were captured in fall (Appendix I). Eighty-four (70.2%) species were common to both seasons; 13 restricted to spring and 21 species to autumn. Over one-third of the species captured (37.3%) had less than 10 individuals taken during the three-year-period and these species accounted for less than 1% of all individuals recorded. The remaining 74 species accounted for 99% of all captures, and 58.3% of all birds taken are attributable to only 12 of those species (Appendix I). Nearctic-Neotropic migrants constituted 66.1% (78/118) of all species captured at Sandrock Cliff (Appendix I). This percentage closely reflects the relative number of Nearctic-Neotropic species (199/312) recorded from the Saint Croix Valley (see Janssen 1987, Robbins 1991). The remaining species include year-round residents (10.1%) and those largely wintering elsewhere within the United States (23.8%). Nearctic-Neotropic migrants comprised the majority of individuals taken in the spring (82.5%), in the fall (68.9%), and overall (72.7%). The percentage differences between spring and fall Neotropic migrant first captures indicate our spring mist-netting period included most of the Neotropic migrant passage, but the fall netting period began after their autumnal passage was underway (Fig. 1). Clearly, Nearctic-Neotropic migrants comprise an important component of the Saint Croix River Valley's terrestrial avifauna and consequently, long term population changes may affect the Saint Croix Valley avifaunal communities in the coming decades. Holmes et al. (1986) have noted such trends at Hubbard Brook Forest in New Hampshire.

Nearctic-Neotropic migrants constitute 61.5% (8/13) of the species taken only in spring and 61.9% (13/21) of those species taken only in the fall. Most species taken in only one season were larger, nocturnal species (e.g., rapters, caprimulgids) or rarer species (e.g., Acadian Flycatcher, Cerulean Warbler, Louisiana Waterthrush) nearing the limits of their continental distribution. However, several species exhibit marked differences in first captures between the two seasons. Some species more commonly encountered in spring than fall (e.g., Golden-winged Warbler, Yellow Warbler, and Indigo Bunting) may have divergent spring and fall migration routes. Alternatively, these species may spend relatively less time on their breeding grounds, arriving later or departing earlier than our netting period encompassed, so that our sampling efforts missed segments of their populations. Encountered in the fall along the Saint Croix River but rarely in the spring are other species, such as Tennessee Warbler, Cape May Warbler, Black-throated Green Warbler, Bay-breasted Warbler, and Blackpoll Warbler (Appendix I). Both Janssen (1987) and Robbins (1991) report these species as fairly common spring and fall migrants throughout the region, and therefore our lack of spring captures is puzzling.

The temporal passage of migrating species over a point on the earth's surface varies as a function of many biotic and abiotic factors. We estimated approximate passage times for all species in which ≥10 individuals were captured at Sandrock Cliff over the six seasons by determining median capture dates (when half of a season's first captures occurred for a given species). Our sampling period did not encompass the entire temporal range of some species in transit. However, a goodly number of individuals from many species were encountered, and with the understanding there were outliers in the temporal distribution of some, reasonable estimates can still be made (Fig. 1). Peak numbers of birds captured (N ≥ 10) in spring at Sandrock Cliff occurred during the middle of May, with a median rapture date of 16 May (Julian date 136). Neotropic migrants had a median capture date of 18 May (Julian date 138). In comparison, the short distance migrants ("temperate migrants"), wintering north of the tropics but mostly south of the winter snow line, had a median capture date of 8 May (Julian date 128). The spring capture (N

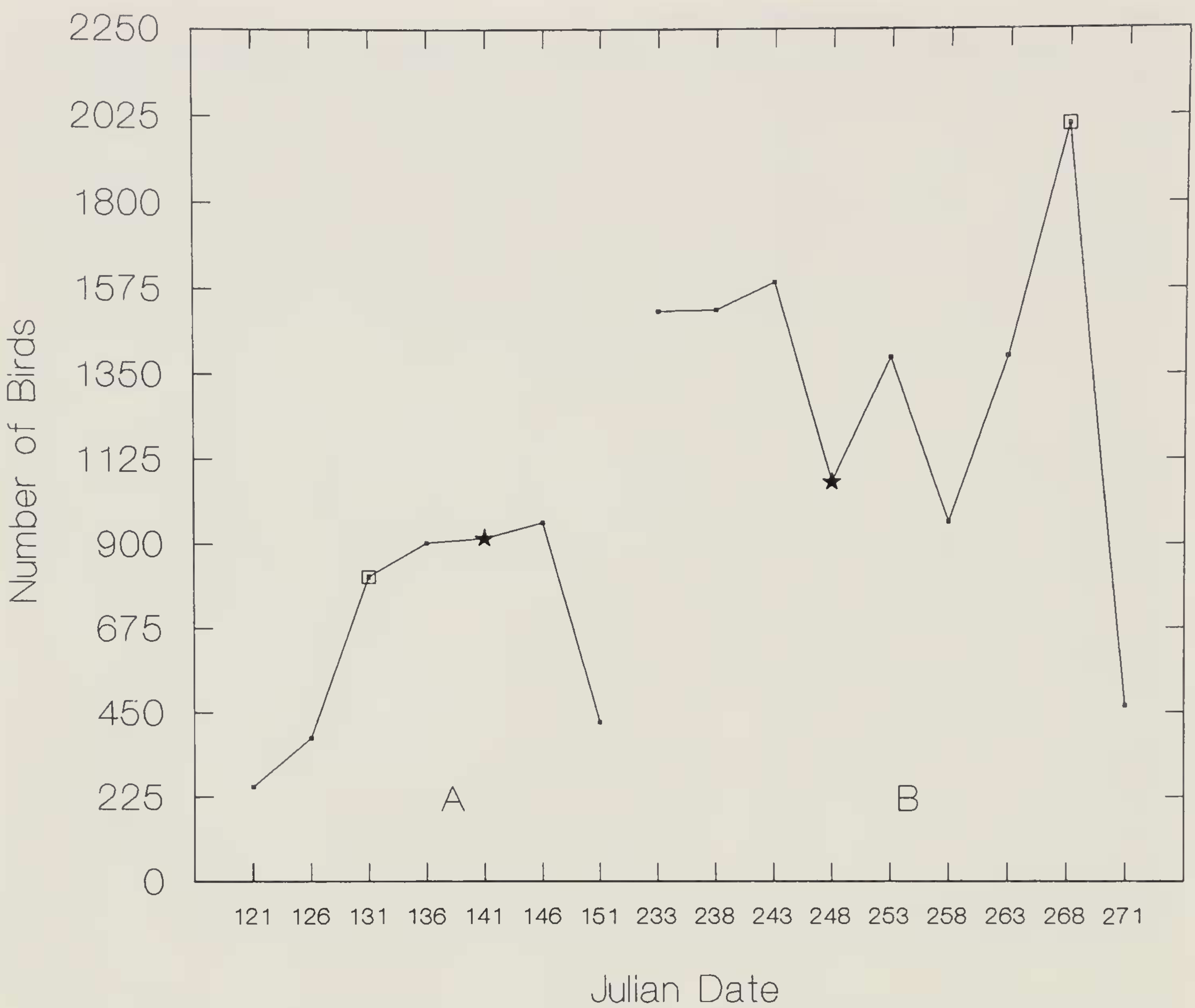

FIG. 1. Distribution of first captures during spring (A) and fall (B) showing total number of individuals caught during five-day time periods for 1985, 1986, and 1987 at Sandrock Cliff (Saint Croix River km 146). Final period in fall lasted only three days. Star (★) denotes time period of Neotropical migrant median capture dates. Square (□) denotes time period of temperate migrant median capture dates. 1 May = Julian date 121, 1 September = Julian date 244.

≥ 10) median differs from Valley Creek, 100 km to the south, where 14 May (Julian date 134) was the median capture date (Winker et al. 1992). Autumn migrants show a similar divergence with median capture dates of 1 Sept. (Julian date 244) for tropical migrants and 22 Sept. (Julian date 265) for temperate migrants. The median capture date for all fall captures was 6 Sept. (Julian date 249). The fall captures also differ by a week from the more southerly Valley Creek site (see Winker et al. 1992), with a median capture date for all species 31 Aug. (Julian date 243, Appendix I).

Francis and Cooke (1986) noted that early arriving spring birds wintered closer than birds arriving at later dates, and similarly in autumn, early arriving migrants winter farther south than the later arriving migrants.

We also found early spring arriving birds were more likely to be temperate migrants and the later arrivals were more likely to be from the tropics. In the fall, tropical migrants were usually encountered earlier than temperate migrants. Some species, notably Yellow-bellied Flycatcher, Golden-winged Warbler, Canada Warbler, and Indigo Bunting were elsewhere for 12–13 weeks, presumably engaged in breeding activities, between median capture dates. In contrast Hermit Thrush, Gray-cheeked Thrush, Orange-crowned Warbler, Palm Warbler, Lincoln's Sparrow, and Swamp Sparrow spent nearly 19–20 weeks between median capture dates (Appendix I). In general, we found that Nearctic-Neotropical migrants had less time, 106 days (about 15 weeks), between spring and fall median capture dates than did temperate migrants, 143 days (about 20 weeks). In other words the spring and fall median capture dates of short distance migrants "bracket" those of Neotropical migrants (Fig. 1).

Our observation of a shorter time period between Neotropic migrants' spring and fall median capture dates indicates they spend less time on their breeding grounds. Conversely, they devote a sizable portion of their life cycles in transit between their northern breeding areas and southern wintering areas. Recher (1966) has noted that many migrant species spend up to 75% of their life cycles migrating and on wintering grounds. Our data suggest some Neotropic migrants spend over 70% of the time elsewhere between fall and spring captures (Appendix I).

Stopover habitat "use" at Sandrock Cliff displays seasonal variation during this three year study (Figs. 2, 3). (We note that "use" in this context is defined as presence in a habitat as indicated by first capture date. We have no direct data pertaining to physiological states or behavior.) Among the six habitats examined, alder swale had the greatest number of both individual and species captures taken in spring and fall while pine forest showed much greater rates in fall than spring. In contrast, the upland forest showed virtually no difference between spring and fall captures and generally had so few animals (<1/day) either season that it was eliminated from further consideration after the first year of study (Figs. 3, 4). All the habitats, except the upland hardwood forest, showed normally expected increases in captures from spring to fall. The pine barren forest particularly exhibited a 5.4 fold increase in individual capture rates and 1.7 fold increase in species taken from spring to fall (a significant difference, $t = 2.337$, $P = 0.019$). Among the other habitats, the alders, fen, showed significant difference between number of species taken spring and autumn ($t = 6.573$ $P = 0.003$, $t = 3.703$ $P = 0.021$, $t = 10.200$ $P = 0.012$ respectively) but none was significantly different in the numbers of individuals taken between spring and fall over the three year period. Neither the floodplain forest nor the upland forest showed significant changes in

FIG. 2. The numbers of birds captured per 1000 net-h during spring (crosshatch) and fall (diagonal) 1985, 1986, and 1987 in six habitats at Sandrock Cliff (Saint Croix River km 146). Data are for first captures only.

species composition or numbers taken between the seasons (Fig. 3). These observations support both Berthold's (1989) similar findings of habitat use patterns among migrating European warblers and are consistent with Winker et al.'s (1992) demonstration of seasonal capture differences in habitats at Valley Creek, 100 km south along the Saint Croix River. It seems probable that some long distance migrating birds use different habitats seasonally in the Saint Croix Valley.

Only six species of the 84 species captured both seasons were taken in two or fewer habitats (Blue-gray Gnatcatcher, Warbling Vireo, Blue-winged Warbler, Yellow Warbler, Louisiana Waterthrush, and Field Sparrow). Except Yellow Warbler, all of these species were uncommon during all seasons (Appendix I). The Yellow Warbler was restricted entirely to the alder swale except for a few fall individuals taken in the sedge fen. The remaining 78 species common to both spring and autumn were found in three or more habitats in one of the seasons. Typically, these species were more widely dispersed in autumn than in spring. Most species tended to be found initially in alder swale and subsequently in the other habitats as those habitats underwent thaw and bud burst.

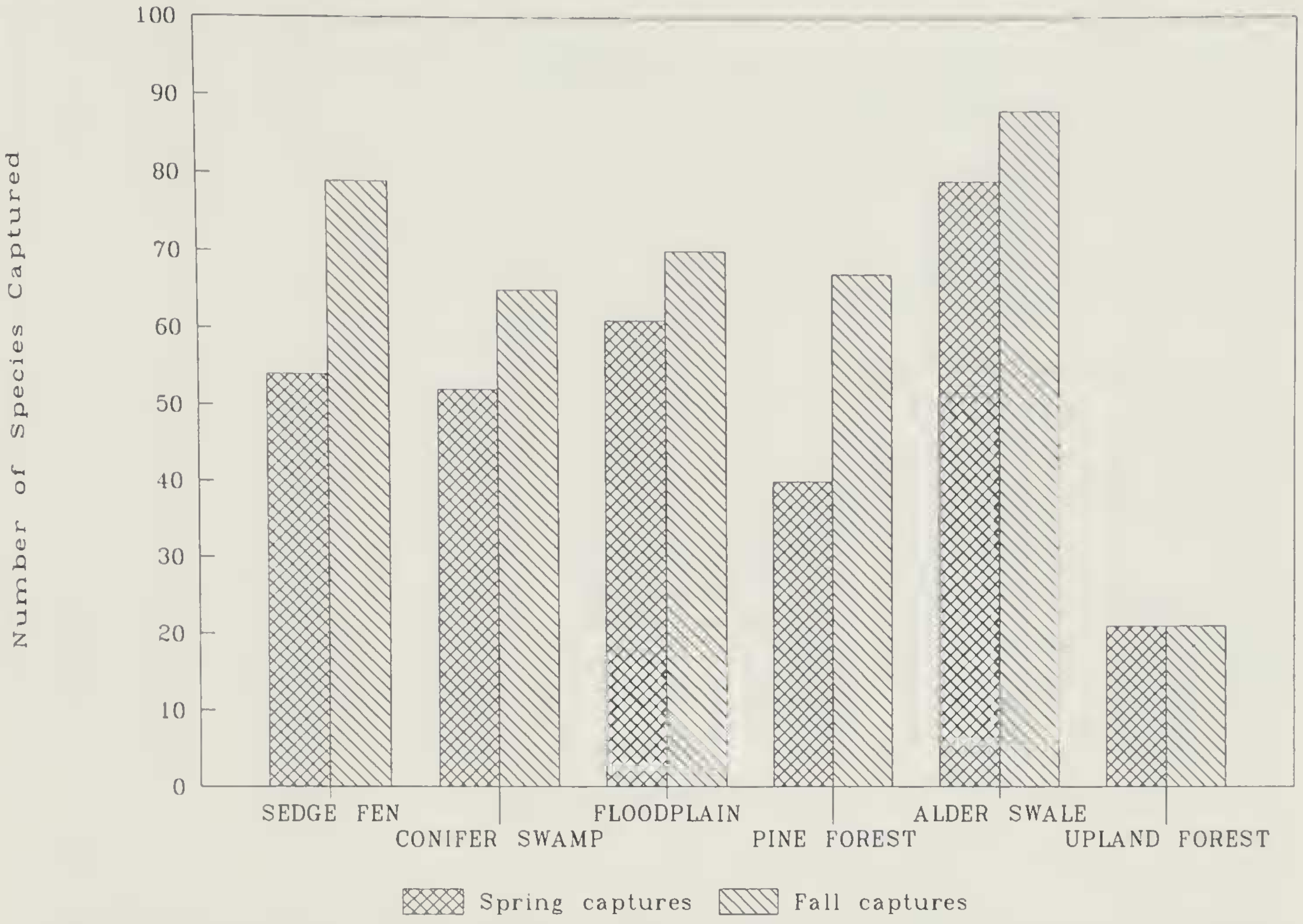

FIG. 3. The numbers of species captured during spring (crosshatch) and fall (diagonal) 1985, 1986, and 1987 in six habitats at Sandrock Cliff (Saint Croix River km 146).

DISCUSSION

The three year bird capture data from the Saint Croix River suggest that migrating land birds exhibit divergent routes between spring and fall passage and that migrants show a seasonal shift in stopover habitat use. The distinct contrast we observed among species in which capture rates differed between seasons may be explained either by natural productivity over the summer or a seasonal shift in passage route. We conservatively assume that natural production may account for a four or five fold increase in capture rates, but as the rate of increase approaches an order of magnitude exhibited by certain species (e.g., Yellow-bellied Flycatcher, Tennessee Warbler, Black-throated Green Warbler, Bay-breasted Warbler, Chipping Sparrow), alternative explanations should be considered. One parsimonious explanation would include seasonal shift in route between spring and fall because if a migrating passerine flies south along 92°W longitude from Sandrock Cliff the equator is crossed in the Pacific Ocean, west of the Galapagos Islands, some 1300 km from South America. Since many Neotropical migrants winter in Central and South America, it seems reasonable to assume they may exhibit an east-west component in their annual passage between their tropical wintering areas and northern summering grounds. Such an east-west component may result in either temporal or geographic divergence and may explain why several long distance migrants were taken primarily during spring or fall but not in both seasons. The same situation was also found by Winker et al. (1992) in which consistent discrepancies between spring and autumn capture rates were reported for many of the same tropical migrants we observed.

A second possible explanation is that small land birds may have "traditional" stopover sites (see Winker et al. 1991), as is true for waterfowl and shorebirds, and that the Sandrock Cliff and Valley Creek sites are not "traditional" spring stopover sites. In any case, these two independent observations of the same phenomenon (including many of the same species, made over the same time period, and in the same region) suggest a number of species have divergent spring and autumn migration routes or stopover patterns, a phenomenon known for other long distance migrating species (e.g., Thompson 1973, Francis and Cooke 1992). It should be noted also that no birds captured and banded at the Valley Creek site were recaptured at Sandrock Cliff or vice versa. These two study sites, 100 km apart, while operating simultaneously during four of six seasons, apparently sampled different segments of migrating bird populations, as if there were lines, passing diagonally across the Saint Croix River Valley.

It is not possible to establish the total number of individuals or species occurring in a habitat, but based upon our captures, we found that stopover habitat use varied considerably among the birds captured at Sandrock Cliff. Over the three year study period some species were confined to one (Yellow Warbler) or two (Louisiana Waterthrush) habitats, while others, e.g., hummingbirds, ovenbirds, and the *Catharus* thrushes, were encountered in all habitats. In general, a distinct shift in captures among habitats occurred from spring to fall across the assemblage of species from springtime bird concentrations in the alders to a strong convergence of birds in the pines during the fall. Such broad shifts in habitat use may occur as a consequence of local microclimatic conditions affecting resource availability, as well as internal physiological or behavioral states of individual birds. If these birds are using the habitats for rest or replenishment, the spring concentrations may reflect early availability of food or shelter, whereas by autumn those habitats with a slower spring phenology have achieved their summer's growth in potential shelter and food sources for the birds. Rappole and Warner (1976) suggested that perhaps one-third of the migrants captured at fall stopover sites used food resources. Burger et al. (1977) noted shorebirds' shifting use of habitats during migration was a function of food availability resulting from tide cycles. We speculate that migrant land birds are capable of making similar, perhaps gradual, shifts over the breeding season as new food sources become available; consequently, they are able to shift readily, within their adaptive range, from one resource base to another (see Tinbergen 1960, Power 1971). Subsequent food and other resource availability studies would be helpful in elucidating this point as suggested by Gauthreaux's (1979) remarks about the role of avian migrations in community ecology. Also needed are studies clarifying physiological states and behavioral conditions correlating with migration stopover activities.

The observed apparent divergence in seasonal migration routes in some species and the shifting habitat use by others suggest that efforts to conserve Nearctic-Neotropic migrating bird populations may require conservation of a wide range of habitats over the entire continental range of these species. Such measures will necessitate detailed examination of species-specific seasonal migration routes, migration timing, and migration habitat requirements to assure that such conserved areas are ecologically appropriate.

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APPENDIX I

SPRING AND FALL MIGRATIONS AT SANDROCK CLIFF, SAINT CROIX NATIONAL RIVERWAY, 1985, 1986, AND 1987

Species	Spring captures					Fall captures				
		Date		Birds/1000 net-h			Date		Birds/1000 net-h	
	N	Range	Median	Mean	Range	N	Range	Median	Mean	Range
Sharp-shinned Hawk (*Accipiter striatus*)*	2	124–126	–	0.02	(0.00–0.04)	16	237–262	255	0.19	(0.09–0.33)
Cooper's Hawk (*A. cooperii*)*	1	117	–	0.01	(0.00–0.03)	0	–	–	–	–
Red-shouldered Hawk (*Buteo lineatus*)	1	123	–	0.01	(0.00–0.04)	0	–	–	–	–
Broad-winged Hawk (*B. platypterus*)*	3	136–144	–	0.04	(0.03–0.04)	7	238–264	–	0.08	(0.03–0.21)
Ruffed Grouse (*Bonasa umbellus*)	0	–	–	–	–	8	239–271	–	0.09	(0.00–0.21)
Sora (*Porzana carolina*)*	0	–	–	–	–	1	264	–	0.01	(0.00–0.03)
American Woodcock (*Scolopax minor*)	1	129	–	0.01	(0.00–0.03)	8	235–271	–	0.09	(0.03–0.17)
Mourning Dove (*Zenaida macroura*)	2	135–147	–	0.02	(0.00–0.04)	0	–	–	–	–
Black-billed Cuckoo (*Coccyzus erythropthalmus*)*	2	141–143	–	0.02	(0.00–0.07)	7	230–257	–	0.08	(0.00–0.17)
Barred Owl (*Strix varia*)	0	–	–	–	–	1	254	–	0.01	(0.00–0.04)
Northern Saw-whet Owl (*Aegolius acadicus*)	9	120–143	–	0.11	(0.00–0.21)	2	264–267	–	0.02	(0.00–0.04)
Common Nighthawk (*Chordeiles minor*)*	0	–	–	–	–	1	238	–	0.01	(0.00–0.03)
Whip-poor-will (*Caprimulgus vociferus*)*	1	127	–	0.01	(0.00–0.04)	0	–	–	–	–
Ruby-throated Hummingbird (*Archilochus colubris*)*	244	127–150	141	2.98	(2.17–4.28)	280	229–256	236	3.25	(2.38–3.67)
Belted Kingfisher (*Ceryle alcyon*)*	0	–	–	–	–	1	251	–	0.01	(0.00–0.04)
Red-headed Woodpecker (*Melanerpes erythrocephalus*)	0	–	–	–	–	1	247	–	0.01	(0.00–0.03)
Red-bellied Woodpecker (*M. carolinus*)	3	137–150	–	0.04	(0.00–0.07)	0	–	–	–	–
Yellow-bellied Sapsucker (*Sphyrapicus varius*)*	6	121–148	–	0.07	(0.00–0.12)	19	233-269	263	0.22	(0.08–0.31)

Appendix I
Continued

Species	Spring captures					Fall captures				
		Date		Birds/1000 net-h			Date		Birds/1000 net-h	
	N	Range	Median	Mean	Range	N	Range	Median	Mean	Range
Downy Woodpecker (*Picoides pubescens*)	21	119–150	136	0.26	(0.10–0.46)	47	229–271	248	0.55	(0.39–0.79)
Hairy Woodpecker (*P. villosus*)	18	120–148	135	0.22	(0.1–0.32)	16	233–268	245	0.19	(0.10–0.29)
Northern Flicker (*Colaptes auratus*)	6	128–144	—	0.07	(0.07–0.08)	5	235–259	—	0.06	(0.03–0.08)
Pileated Woodpecker (*Dryocopus pileatus*)	1	128	—	0.01	(0.00–0.03)	1	254	—	0.01	(0.00–0.03)
Olive-sided Flycatcher (*Contopus borealis*)*	1	141	—	0.01	(0.00–0.04)	5	234–237	—	0.06	(0.03–0.10)
Eastern Wood-Pewee (*C. virens*)*	1	149	—	0.01	(0.00–0.04)	38	230–267	238	0.44	(0.38–0.48)
Yellow-bellied Flycatcher (*Empidonax flaviventris*)*	13	135–150	148	0.16	(0.00–0.35)	118	229–261	236	1.37	(0.71–1.64)
Acadian Flycatcher (*E. virescens*)*	0	—	—	—	—	1	255	—	0.01	(0.00–0.03)
"Traill's" Flycatcher (*E. "traillii complex"*)*	96	125–151	143	1.17	(0.91–1.53)	130	299–264	240	1.51	(1.06–1.85)
Least Flycatcher (*E. minimus*)*	118	120–150	135	1.44	(1.15–1.85)	245	229–267	240	2.84	(1.38–4.05)
Eastern Phoebe (*Sayornis phoebe*)*	11	120–137	125	0.13	(0.10–0.16)	41	229–270	239	0.48	(0.17–0.73)
Great Crested Flycatcher (*Myiarchus crinitus*)*	9	130–151	—	0.11	(0.10–0.12)	10	229–260	238	0.12	(0.04–0.21)
Northern Rough-winged Swallow (*Stelgidopteryx serripennis*)*	4	118–144	—	0.05	(0.00–0.12)	1	233	—	0.01	(0.00–0.03)
Barn Swallow (*Hirundo rustica*)*	1	137	—	0.01	(0.00–0.03)	0	—	—	—	—
Blue Jay (*Cyanocitta cristata*)	18	119–146	127	0.22	(0.14–0.32)	89	234–268	259	1.03	(0.36–1.75)
Black-capped Chickadee (*Parus atricapillus*)	47	118–148	123	0.57	(0.42–0.84)	248	229–270	244	2.88	(2.09–4.43)
Red-breasted Nuthatch (*Sitta canadensis*)	1	122	—	0.01	(0.00–0.03)	48	229–271	245	0.56	(0.27–0.75)

APPENDIX I
CONTINUED

Species	Spring captures					Fall captures				
		Date		Birds/1000 net-h			Date		Birds/1000 net-h	
	N	Range	Median	Mean	Range	N	Range	Median	Mean	Range
White-breasted Nuthatch (*S. carolinensis*)	9	123–142	—	0.11	(0.00–0.21)	42	229–268	236	0.49	(0.34–0.67)
Brown Creeper (*Certhia americana*)	14	117–137	123	0.17	(0.14–0.21)	175	229–271	259	2.03	(1.5–2.33)
Carolina Wren (*Thryothorus ludovicianus*)	1	139	—	0.01	(0.00–0.03)	0	—	—	—	—
House Wren (*Troglodytes aedon*)*	25	119–148	130	0.31	(0.07–0.49)	14	233–267	243	0.16	(0.08–0.27)
Winter Wren (*T. troglodytes*)	5	117–148	—	0.06	(0.04–0.07)	81	229–271	262	0.94	(0.38–1.63)
Sedge Wren (*Cistothorus platensis*)*	0	—	—	—	—	5	243–268	—	0.06	(0.00–0.09)
Marsh Wren (*C. palustris*)*	1	123	—	0.01	(0.00–0.04)	0	—	—	—	—
Golden-crowned Kinglet (*Regulus satrapa*)	0	—	—	—	—	145	257–271	268	1.68	(0.00–3.54)
Ruby-crowned Kinglet (*R. calendula*)	104	117–145	126	1.27	(0.63–2.03)	395	234–271	266	4.58	(1.25–7.65)
Blue-gray Gnatcatcher (*Polioptila caerulea*)*	3	128–133	—	0.04	(0.00–0.07)	2	234–238	—	0.02	(0.00–0.04)
Eastern Bluebird (*Sialia sialis*)*	2	133–144	—	0.02	(0.00–0.04)	1	262	—	0.01	(0.00–0.03)
Veery (*Catharus fuscescens*)*	98	125–151	140	1.20	(0.94–1.51)	107	229–266	239	1.24	(1.09–1.42)
Gray-cheeked Thrush (*C. minimus*)*	48	126–145	136	0.59	(0.4–0.77)	39	229–265	257	0.45	(0.36–0.62)
Swainson's Thrush (*C. ustulatus*)*	78	122–149	134	0.95	(0.66–1.21)	455	229–269	251	5.28	(3.29–7.56)
Hermit Thrush (*C. guttatus*)*	26	118–129	120	0.32	(0.14–0.44)	69	230–271	264	0.80	(0.17–1.75)
Wood Thrush (*Hylocichla mustelina*)*	24	126–149	133	0.29	(0.14–0.46)	32	231–259	239	0.37	(0.14–0.67)
American Robin (*Turdus migratorius*)*	6	117–143	—	0.07	(0.04–0.12)	13	247–270	261	0.15	(0.04–0.30)
Gray Catbird (*Dumetella carolinensis*)*	116	125–150	137	1.42	(0.91–1.77)	58	230–267	243	0.67	(0.54–0.72)
Brown Thrasher (*Toxostoma rufum*)	0	—	—	—	—	1	255	—	0.01	(0.00–0.04)
Cedar Waxwing (*Bombycilla cedrorum*)*	31	140–150	146	0.38	(0.28–0.44)	146	229–267	237	1.69	(0.92–2.45)
Solitary Vireo (*Vireo solitarius*)*	8	124–140	—	0.10	(0.07–0.14)	119	231–271	254	1.38	(1.25–1.58)

Appendix I
Continued

Species	Spring captures					Fall captures				
		Date		Birds/1000 net-h			Date		Birds/1000 net-h	
	N	Range	Median	Mean	Range	N	Range	Median	Mean	Range
Yellow-throated Vireo (*V. flavifrons*)*	5	132–142	—	0.06	(0.00–0.16)	29	229–259	239	0.34	(0.30–0.38)
Warbling Vireo (*V. gilvus*)*	1	139	—	0.01	(0.00–0.03)	2	231–248	—	0.02	(0.00–0.04)
Philadelphia Vireo (*V. philadelphicus*)*	4	130–143	—	0.05	(0.00–0.12)	79	229–267	253	0.92	(0.79–1.17)
Red-eyed Vireo (*V. olivaceus*)*	164	129–150	142	2.00	(1.01–2.98)	508	229–268	238	5.89	(3.99–8.31)
Blue-winged Warbler (*Vermivora pinus*)*	2	144	—	0.02	(0.00–0.04)	1	241	—	0.01	(0.00–0.04)
Golden-winged Warbler (*V. chrysoptera*)*	130	125–151	145	1.59	(1.23–2.17)	99	230–244	236	1.15	(0.76–1.40)
"Brewster's" Warbler (*V. "leucobronchialis"*)*	1	127	—	0.01	(0.00–0.04)	2	230–260	—	0.02	(0.00–0.04)
Tennessee Warbler (*V. peregrina*)*	26	125–146	137	0.32	(0.04–0.52)	547	230–271	248	6.34	(2.88–9.77)
Orange-crowned Warbler (*V. celata*)*	23	121–134	130	0.28	(0.10–0.64)	50	244–271	264	0.58	(0.17–1.00)
Nashville Warbler (*V. ruficapilla*)*	231	118–150	130	2.82	(1.61–3.76)	1068	229–271	248	12.39	(10.69–14.15)
Northern Parula (*Parula americana*)*	0	—	—	—	—	6	239–271	—	0.07	(0.00–0.12)
Yellow Warbler (*Dendroica petechia*)*	183	123–151	139	2.23	(1.47–3.50)	29	229–268	242	0.34	(0.3–0.42)
Chestnut-sided Warbler (*D. pensylvanica*)*	111	127–150	139	1.35	(1.12–1.61)	311	229–265	244	3.61	(2.81–4.76)
Magnolia Warbler (*D. magnolia*)*	63	126–150	137	0.77	(0.53–1.25)	494	229–268	253	5.73	(3.84–7.50)
Cape May Warbler (*D. tigrina*)*	0	—	—	—	—	25	230–266	242	0.29	(0.24–0.42)
Black-throated Blue Warbler (*D. caerulescens*)*	0	—	—	—	—	4	240–261	—	0.05	(0.03–0.08)
Yellow-rumped Warbler (*D. coronata*)	87	118–140	120	1.06	(0.00–3.06)	1696	229–271	266	19.67	(0.75–39.87)
Black-throated Green Warbler (*D. virens*)*	1	130	—	0.01	(0.00–0.03)	25	229–263	243	0.29	(0.21–0.34)

Appendix I
Continued

Species	Spring captures					Fall captures				
		Date		Birds/1000 net-h			Date		Birds/1000 net-h	
	N	Range	Median	Mean	Range	N	Range	Median	Mean	Range
Blackburnian Warbler (*D. fusca*)*	3	143–150	—	0.04	(0.00–0.08)	19	232–262	236	0.22	(0.10–0.38)
Pine Warbler (*D. pinus*)	12	123–137	129	0.15	(0.04–0.25)	12	231–264	241	0.14	(0.00–0.21)
Palm Warbler (*D. palmarum*)*	51	118–140	129	0.62	(0.21–1.25)	83	234–271	264	0.96	(0.08–1.87)
Bay-breasted Warbler (*D. castanea*)*	0	—	—	—	—	118	230–265	253	1.37	(0.60–2.38)
Blackpoll Warbler (*D. striata*)*	1	124	—	0.01	(0.00–0.04)	77	230–267	259	0.89	(0.38–1.27)
Cerulean Warbler (*D. cerulea*)*	0	—	—	—	—	1	238	—	0.01	(0.00–0.03)
Black-and-white Warbler (*Mniotilta varia*)*	44	117–147	136	0.54	(0.39–0.76)	128	229–271	243	1.48	(1.34–1.88)
American Redstart (*Setophaga ruticilla*)*	226	127–150	140	2.76	(2.41–3.23)	354	229–265	241	4.11	(3.51–4.83)
Prothonotary Warbler (*Protonotaria citrea*)*	1	139	—	0.01	(0.00–0.04)	0	—	—	—	—
Ovenbird (*Seiurus aurocapillus*)*	215	118–149	133	2.62	(1.99–3.79)	595	229–271	241	6.90	(6.44–7.85)
Northern Waterthrush (*S. noveboracensis*)*	219	121–148	131	2.67	(2.21–3.66)	344	229–270	243	3.99	(2.23–5.47)
Louisiana Waterthrush (*S. motacilla*)*	9	124–147	—	0.11	(0.04–0.17)	3	232–241	—	0.03	(0.00–0.09)
Connecticut Warbler (*Oporornis agilis*)*	6	138–148	—	0.07	(0.07–0.08)	24	232–263	244	0.28	(0.15–0.45)
Mourning Warbler (*O. philadelphia*)*	57	126–150	132	0.70	(0.44–1.02)	64	229–263	238	0.74	(0.62–0.96)
Common Yellowthroat (*Geothlypis trichas*)*	672	124–151	140	8.20	(6.85–10.26)	560	229–270	240	6.49	(6.30–6.86)
Wilson's Warbler (*Wilsonia pusilla*)*	66	128–149	140	0.81	(0.45–1.09)	87	229–265	243	1.01	(0.85–1.25)
Canada Warbler (*W. canadensis*)*	55	131–150	143	0.67	(0.31–0.91)	130	229–265	238	1.51	(1.03–1.92)
Scarlet Tanager (*Piranga olivacea*)*	21	132–150	142	0.26	(0.08–0.46)	50	230–264	240	0.58	(0.30–0.99)
Northern Cardinal (*Cardinalis carindalis*)	1	123	—	0.01	(0.00–0.04)	0	—	—	—	—

Appendix I
Continued

Species	Spring captures					Fall captures				
		Date		Birds/1000 net-h			Date		Birds/1000 net-h	
	N	Range	Median	Mean	Range	N	Range	Median	Mean	Range
Rose-breasted Grosbeak (*Pheucticus ludovicianus*)*	18	129–146	139	0.22	(0.14–0.36)	87	229–265	239	1.01	(0.97–1.04)
Indigo Bunting (*Passerina cyanea*)*	85	132–150	142	1.04	(0.76–1.33)	13	232–255	233	0.15	(0.00–0.33)
Rufous-sided Towhee (*Pipilo erythrophthalmus*)*	0	—	—	—	—	1	249	—	0.01	(0.00–0.04)
Chipping sparrow (*Spizella passerina*)*	53	119–147	133	0.65	(0.32–0.93)	5	241–248	—	0.06	(0.00–0.15)
Clay-colored Sparrow (*S. pallida*)*	10	127–143	131	0.12	(0.07–0.20)	3	245–254	—	0.03	(0.00–0.06)
Field Sparrow (*S. pusilla*)*	10	121–148	140	0.12	(0.08–0.14)	1	247	—	0.01	(0.00–0.03)
Vesper Sparrow (*Pooecetes gramineus*)*	1	125	—	0.01	(0.00–0.04)	0	—	—	—	—
Savannah Sparrow (*Passerculus sandwichensis*)*	1	124	—	0.01	(0.00–0.03)	3	252–263	—	0.03	(0.00–0.08)
Baird's Sparrow (*Ammodramus bairdii*)*	0	—	—	—	—	1	254	—	0.01	(0.00–0.03)
Henslow's Sparrow (*A. henslowii*)	1	146	—	0.01	(0.00–0.04)	1	232	—	0.01	(0.00–0.03)
Fox Sparrow (*Passerella iliaca*)	1	127	—	0.01	(0.00–0.03)	33	256–271	267	0.38	(0.00–0.91)
Song Sparrow (*Melospiza melodia*)	166	117–150	140	2.03	(1.58–2.70)	98	229–271	238	1.14	(0.89–1.39)
Lincoln's Sparrow (*M. lincolnii*)*	17	118–142	129	0.21	(0.14–0.24)	54	229–270	253	0.63	(0.25–0.79)
Swamp Sparrow (*M. georgiana*)*	57	119–145	127	0.70	(0.21–0.98)	123	229–271	258	1.43	(0.38–1.88)
White-throated Sparrow (*Zonotrichia albicollis*)	97	118–136	126	1.18	(1.01–1.40)	269	233-271	259	3.12	(1.29–4.35)
White-crowned Sparrow (*Z. leucophrys*)	10	124–133	129	0.12	(0.07–0.20)	4	253–270	—	0.05	(0.00–0.07)

APPENDIX I
CONTINUED

Species	Spring captures					Fall captures				
		Date		Birds/1000 net-h			Date		Birds/1000 net-h	
	N	Range	Median	Mean	Range	N	Range	Median	Mean	Range
Dark-eyed Junco (*Junco hyemalis*)	2	118	—	0.02	(0.00–0.08)	56	239–270	267	0.65	(0.17–1.21)
Red-winged Blackbird (*Agelaius phoeniceus*)*	2	134–141	—	0.02	(0.00–0.08)	0	—	—	—	—
Brown-headed Cowbird (*Molothrus ater*)*	7	121–144	—	0.09	(0.03–0.12)	0	—	—	—	—
Northern Oriole (*Icterus galbula*)*	0	—	—	—	—	2	233–237	—	0.02	(0.00–0.06)
Purple Finch (*Carpodacus purpureus*)	23	123–145	133	0.28	(0.07–0.60)	74	229–265	241	0.86	(0.33–1.38)
White-winged Crossbill (*Loxia leucoptera*)	0	—	—	—	—	1	263	—	0.01	(0.00–0.03)
Pine Siskin (*Carduelis pinus*)	0	—	—	—	—	19	256–268	267	0.22	(0.00–0.65)
American Goldfinch (*C. tristis*)	153	120–150	138	1.87	(1.12–2.53)	103	229–265	239	1.19	(0.67–1.51)
Evening Grosbeak (*Coccothraustes vespertinus*)	0	—	—	—	—	13	240–264	243	0.15	(0.00–0.41)
Total species	97					105				
Total captures	4645					11,882				

Number of individuals taken is for first capture only. Julian dates are used where 1 May = 121 and 1 September = 244. Median Capture dates are noted for those species where $N \geq 10$ over the three year period. Asterisk (*) denotes Nearctic-Neotropical migrant (after Rappole et al. 1983:108). Pound sign (#) denotes hummingbirds. Hummingbirds were not banded; consequently, data presented here include some recaptured individuals.